THE SUCCESS FACTORS OF BIOMASS ENERGY PROJECTS:

Case studies

By

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1. INTRODUCTION

The topic of this research is biomass energy and their success factors in projects. The world is embracing this model of getting energy as an alternative source. All the concepts and issues related to using the biomass as an alternative source of energy are discussed in this paper. Non renewable energy sources such as coal, natural gas, and oil are hazardous to the environment due to the emissions of their produce. As these fuels are non renewable, one may run out of them in future. This has led to the increased development of the renewable energy sources. Present technological advances in renewable energy sources make them more cost-effective and efficient than in the past. Renewable energy sources are any sources of energy that can be utilized without depleting their reserves. Renewable energy sources include micro/mini hydro power, wind energy, geothermal, solar energy, and biomass. Biomass has a broad range of uses and users – bio-energy is one utilization pathway, but biomass is also used for human food, animal feed, materials and chemicals, and bio-energy interacts with all these areas. Often, the interactions are synergistic but they may also be in conflict (Kautto 2011). This thesis treats biomass as it is used for energy production only.

This paper lays the foundation of the research project. It begins with a definition of biomass energy. This is followed with some statistics on the importance of biomass energy worldwide. A discussion of the different types and sources of biomass energy is then given. The pros and cons of biomass energy regard with risks and benefits are then discussed, and follow that advantages and disadvantages of biomass energy. A comparison of biomass energy to other types of energy is made. As a methodology four case studies from Canada and one from Brazil are discussed.

Analysis of success and failure factors including recommendation which is my contribution is provided and finally summarizing and concluding remarks are provided.

2 What is biomass and biomass energy

There are hundreds, if not thousands, of articles available in print or on the web on the use of biomass for fuels or power production. Most of these have appeared over the past three decades since it was determined that global warming is occurring and the burning of fossil fuels is partly or largely to blame. Immediately, articles started to appear proposing or experimenting with alternative energy sources, including biomass. This literature summarizes information on sources and type of biomass, followed by ways of converting the biomass into energy for various purposes with risks and benefits includes analysis of success and failures factors. Relatively few, selected references are provided in the following chapters.

2.1 Definition of biomass energy and biomass

Biomass energy, from bio – short for biological, + mass – is potential energy stored in organic carbon compounds produced originally through photosynthesis by living organisms, i.e., plants. Biomass can be defined as any organic matter which is available on a renewable basis. This includes residues of forests, municipal wastes, crops and waste of the agriculture field, aquatic plants, wood and waste of wood, residue of livestock operation, and animal wastes. Biomass can be processed into energy, biomaterials, or biofuels, or burned to produce heat or electricity. In addition to its energy application, biomass has a variety of other uses such as food and feed, forestry products (pulp wood), and other industrial applications that are important to the economy. Biomass energy is defined as the energy, fuel or steam that is derived as a result of the direct combustion of the biomass for the purpose of generating electricity, mechanical power, or industrial process heat (Craig 1998).

Biomass is thus a term for all organic material that comes originally from plants. Another way of stating, it is that biomass is the dry weight of all organic material, living or dead, above or below the soil surface (Natural Resources Canada 2003). Biomass is produced by green plants converting sunlight into plant material through photosynthesis and includes all land- and water-based vegetation (trees, agricultural crops, algae), as well as all natural organic wastes. Biomass resource can be considered as organic matter in which the energy of sunlight is stored in chemical bonds. When the bonds between adjacent carbon, hydrogen and oxygen molecules are broken by digestion, combustion, or decomposition, these substances release their stored, chemical energy. Besides plants, organic carbon compounds are found in other types of organisms. The compounds are transferred to and transformed in animals that feed on plants or on each other. Both animals and plants eventually die and decompose by the action of fungi and bacteria, unless they are fossilized before they can decompose. Animal waste products, such as solids (manure), liquids (urine), or, potentially, also gas (flatulence produced during food digestion) are also sources of organic carbon compounds.

This complicates the economic analyses of biomass feed stocks and requires that we differentiate what is technically possible from what is economically feasible, taking into account relative prices and inter-market competition (BR&Di 2008).

2.2 History and importance of biomass

Biomass has always been a major source of energy for mankind and is presently estimated to contribute around 10–14% of the world's energy supply (McKendry 2002). Biomass fuel is the oldest renewable energy resources, going back to cave dwellers. This biomass energy (bioenergy) was probably always extracted by burning non-fossil, natural organic materials found lying around in the environment such as wood and grass or straw. Then, when humans invented agriculture and perhaps forestry (about 10,000 years ago) from these sources, which could include plant oils and vegetable waste. Biomass is therefore also called homegrown energy. Since the industrial revolution several hundred years ago the most important form of biomass energy, particularly in industrialized countries, is fossil fuels, i.e., organic carbon energy stored over geological time as coal, oil, and natural gas. Although this fossil fuel energy is technically biomass energy it is not treated as biomass energy for the purposes of this study. This type of biomass energy is not fossilized because it has not had millions of years under the appropriate conditions to be converted slowly into coal, oil or natural gas.

The energy from fossil fuels and bio-energy both come originally from solar energy (sunlight) converted into chemical compounds of carbon in plants through photosynthesis. The main difference between the two forms of energy is that fossil fuels are extracted from the ground (by mining, etc.) after millions of years there before being converted into usable energy today and the fuels are irreplaceable, whereas energy from living or recently dead plants is biomass that is renewable and, if well managed, can be used on a continuous basis.

In this thesis the phrase 'biomass energy' is used only for energy obtained from organisms (plant or animal) or their residues, i.e., during the extent of recorded human history (over the past few thousand years).

Biomass has been used as an energy source ever since humans discovered the use of fire for heating their dwellings and for cooking, probably for tens of thousands of years. The people in developing countries still rely heavily on biomass (mostly wood) as a source of energy; this represented about 43% of their energy consumption in 1978 whereas in developed countries only 1% was derived from biomass (Hall and Moss 1983). The problem is that in many places people are burning wood and destroying forests at a faster rate than it is replenished, so they are causing serious environmental damage: deforestation, biodiversity loss, desertification, and degradation of water sources.

Since the industrial revolution in more developed countries, industry, particularly the pulp, paper and lumber industries, have used biomass for generating heat and power. These biomass materials are processed to produce solid, liquid and gaseous forms of waste. In theory, this biomass material will never be depleted because it is a renewable source that can be replenished by growing trees in forests or plantations. So, in terms of potential, biomass is considered very useful because it supposedly does not harm the environment and is renewable. Biomass is available in both developed and developing countries (except those that are mostly desert) and hence it can, in theory, meet their energy requirements. Moreover, the biomass is claimed to be environmentally safe because it does not add to the emission of the greenhouse gases.

In the late1970s the global distribution of energy supply from biomass was 14% of total energy use, equivalent to 1000 million tons of oil each year (Hall and Moss 1983). A summary of the proportion of biomass energy in four developed countries was: Finland 18%, Ireland 16%, Sweden 9%, and USA 3%. The corresponding numbers for developing countries was: Kenya 75%, India 50%, China 33%, and Brazil 25% (Hall and Moss 1983).

By 2003, more than 15% of the total world's energy supply was generated from biomass. The percentage for developing countries still remains higher, i.e., 45%, than for developed counties, which burn more fossil energy (oil, natural gas, or coal). The reason it is higher in developing countries today as well as in the 1970s is that cooking and heating is done mainly using biomass energy (FAO 2003). In Tanzania, for example, about 97% of all annual wood production is consumed in the form of wood fuel, accounting for 91% of Tanzania's total energy production (Abdallah and Monela 2007, Campbell et al. 2006).

For the past two decades, the most commonly used **renewable** energy in industrialized countries has been biomass energy. It is the most abundant and extensively used renewable energy source and is the second most important form of renewable energy after hydropower. Biomass energy is being used extensively by the industrial sector mainly for two reasons. The first is that biomass energy is (supposedly) economical. The second is that the worry of over exploitation of fossil fuels has prompted society to investigate alternate energy sources that are renewable, including biomass energy. For example, the USA is increasingly dependent on imported petroleum to meet its energy needs. A roadmap for bioenergy and biobased products was therefore produced to suggest ways or reducing this dependence (BRDTAC. 2007).

Three examples of the importance of biomass as a source of energy are given here. In Brazil, the second largest ethanol producer after the U.S., sugarcane is the dominant feed stock (Hira and de Oliveira 2009). Production of ethanol in Brazil comes mainly from fresh sugarcane juice (79%), with the balance coming from molasses by-products. The conversion of sugarcane to ethanol has proven least costly compared to other feed stocks used for ethanol. (Kojima et al 2007). Report for the financial costs of ethanol production in Brazil ranging from $0.87 to $1.10 per gallon in 2005. Out of a total cost of $1.10, variable costs are 89 cents and fixed costs are 21 cents. One contributing factor to the low fixed cost is that many installations were built with subsidies in the 1980s and are now completely depreciated. These ethanol cost levels are equivalent to gasoline prices when crude oil is $35-$50 per barrel. By comparison, variable costs of corn ethanol in the U.S. average $0.96 per gallon, and fixed costs range from $1.05 to $3.00 per gallon. (Martines-Filho, et al. 2006).

Feedstock costs account for 55–65% of the cost of ethanol production in Brazil. The cost of sugarcane production is thus critical, and Brazil boasts the lowest production costs for this crop in the world. The simpler processing of sugarcane (compared to starch crops) and the availability of free fuel in bagasse (left over from the sugarcane after sugar juice is extracted) also contribute to the cost advantage of producing ethanol from sugar cane versus other feedstocks. Bagasse can be used as a fuel for heat and power generation, and is significant in the economics and energetic of producing ethanol from sugarcane. The processing of 1 ton of sugarcane produces about 260 kg of bagasse, with 13% dry fiber and 50% average moisture. Also, about kilo joule (KJ) of steam is obtained from each kilogram of burned fiber. As a result, sugarcane mill and distilleries are nearly entirely self-sufficient in energy, and a few plants sell surplus electricity (Martines-Filho et al. 2006).

Another feature of sugarcane-based ethanol is the production and disposal of vinasse (the residue liquid from the distillation of ethanol, rich in potassium and organic matter). For each gallon of ethanol sugarcane, distilleries produce 37.9–53.1 gallons of vinasse rich in biochemical oxygen. The discharge of so much vinasse into streams is detrimental to the environment. However, applying vinasse to the soil through irrigation has become more common since Brazil has toughened laws against discharge into streams. Filtercake, another sugarcane waste, is also recycled as fertilizer. These practices have resulted in reduced application of fertilizers in Brazil.

Ethanol production from sugarcane in Brazil was 4.2 billion gallons in 2006, requiring around 3 million hectares out of a total sugarcane crop area of 5.6 million hectares (for sugar and ethanol) (or 10% of total cultivated land in Brazil) (Goldemberg, 2007).

Sugarcane plantations in Brazil are concentrated in the Central South (State of Sao Paulo) and Northeast and have been increasing since the 1970s, mostly through crop substitution (from coffee plantations to sugarcane) and conversion of pasture (Macedo, 2005).

In 1975, 91 million tons of sugarcane was produced, yielding 6 million tons of sugar and 145.1 million gallons of ethanol. In 2002, sugarcane production reached 320 million tons, yielding 22.3 million tons of sugar and 3.32 billion gallons of ethanol. Sugarcane yields have also been increasing, reaching an average of 70 green tons/ha in2003, compared with 50 tons/ha in the mid-1970s. Nearly all cane fields in the Center-South of Brazil is rain fed. This is a marked advantage over other cane growers that rely on irrigation, such as in Australia and India. Productivity in Brazil has also benefited from decades of research and commercial cultivation. For example, cane growers in Brazil use more than 500 commercial cane varieties that are resistant to many of the 40 or so crop diseases found in the country.

In Canada, energy obtained and consumed from biomass is 540 PJ (Peta Joule= 10^{15} Joules = about 128 tons of TNT). This already exceeds the energy produced by coal (for non-electrical generation applications) and nuclear energy. Biomass represents 5% of secondary energy use in the residential sector and 17% of the industrial sector, especially in forest industries. If lumber, pulp and paper, are included, forestry accounts for 35% of the total energy consumption in Canada. Forest industries increased by increasing their consumption of wood waste, previously burned or buried, especially for heating boilers in pulp and paper mills and process heat and energy required for drying wood (Gallagher et al. 2003). In some provinces (British Columbia, Ontario, Quebec, Prince Edward Island and New Brunswick), the forest industry provides wood residues, chips and pellets to industrial consumers who use these for purposes other than electricity. Wood is also the main fuel used for heating in more than 100,000 Canadian homes. In millions more homes, it is a supplemental heating fuel, although fireplaces there have primarily a decorative function. Most official estimates understate the residential consumption of firewood because much is harvested and used locally and does not appear in tax records or in government statistics.

In various African countries more than 90% the primary energy source is woody biomass and is used for mainly cooking purposes. In these countries wood was, and sometimes still is, burned to produce steam for electricity generation (Abdallah and Monela 2007).

2.3 Types of Biomass

Biomass is all biologically-produced matter based in carbon, hydrogen and oxygen. The estimated biomass production in the world is 146 billion tons a year, consisting of mostly wild plant growth (Wikipedia 2013a). Obviously, only a fraction of this biomass is used for energy production.

There are several types of biomass used today for energy production (McKendry 2002, Union of Concerned Scientists 2013): Biomass resources include 1) energy crops, 2) grasses, 3) agricultural crops and their residues, 4) animal waste, i.e., manure (farm animal solid waste and sewage), poultry litter, and even human waste 5) woody biomass (forest residues), and 6) municipal waste (garbage) (food industry waste, domestic waste and industrial organic waste, and landfill gases produced when buried solid waste (garbage) is partly converted into landfill gases by bacterial action. These types are discussed below.

In Canada, the major sources of biomass fuel used include agricultural waste, forest residues, urban wood residues and wood processing residues. Before coal was discovered as an energy source for industry, charcoal, produced by slow heating of wood or other substances in the absence of oxygen, was used. Charcoal is still extensively used in light industry and in smelting metals. Both industry and households still make use of wood for energy in many places. The potential of agricultural biomass is much more limited than that of forest biomass. Most agricultural residues used as fodder or soil conditioners and have a much lower potential energy than wood. (1 m^3 of wood provides as much energy as 5–10 m^3 of compacted agricultural residues).

2.3.1 Energy crops

Energy crops are an important source of biomass. There has been increased interest in their use since the mid-1980s and of 35 potential herbaceous crops tested it was concluded that switch grass (*Panicum virgatum*) showed the greatest potential (Lewandowski et al. 2003). Energy crops can be planted in farms in such a way that the space needed for food crops is not affected, i.e., they can be grown on marginal lands or pastures or placed in rotation with food crops. These sources could contribute significantly to alternative source of energy if they are harvested in a sustainable manner (Ruttan 2008). Energy crops are fast-growing crops grown for the specific purpose of producing liquid fuels from all or part of the plant or burning it to produce electricity. The cost of the energy crops varies with the type of plant grown, method of harvesting, environment, and number of acres under cultivation. Energy crops include *Miscanthus*, a genus of about 15 species of perennial, mainly subtropical and tropical grasses from the Old World

(Scurlock 1999) and sweet sorghum (Sweet Sorghun Ethanol Association 2013). Examples of industrial crops are kenaf (Danalatos 2010) and aquatic plants (Dismukes et al. 2008, Scott et al. 2010). The cost of using energy crops is high compared to the agricultural residues because the agricultural residues are the remaining waste products after harvesting where as the energy crops are grown with the sole aim of producing energy. However, some calculations suggest that at farmgate prices of US $2.44/GJ, an estimated 17 million hectares of bioenergy crops, annually yielding 171 million tons of dry biomass, could potentially be produced at a profit greater than existing agricultural uses for the land. The estimate assumes high productivity management practices are permitted on Conservation Reserve Program lands (Walsh et al. 2003).

2.3.2 Grasses

Grasses are another important source of biomass. The US prairies were covered by thin stemmed perennial grasses before being replaced with food crops. Grasses such as big bluestem (NIFA-AFRI 2012), switch grass (Samson 2007), and similar species grow in different parts of the USA and may be harvested for more than 10 years before they need replanting. Bamboo (Carney 2011) also has good potential as a biomass resource for producing biofuels. The climate of Hawaii and Florida are considered best for growing grasses like Elephant Grass and Sugar Cane. Grasses that are native to a region need fewer inputs for growth and they pose no threat to agro ecosystems. Switch Grass does not dry due to droughts, floods and poor soils. It grows well in the Great Plains, South and Midwest. It is a hardy plant that is resistant to floods, droughts, nutrient poor soils and pests and does not require much fertilizer to produce consistent high yields. Switch Grass is grown all over the world, mainly to feed animals and to keep the land fertile because it is deep rooted.

2.3.3 Agricultural crops and crop residues

Large amounts of residue are produced during agricultural harvesting and other operations. For example, in China Agricultural residues are the major source on non-plantation biomass energy sources, accounting for about 71% in 1997 and projected to be 60% of the total in 2010 (Li et al. 2005). High yielding agricultural crops (NOT their residues) such as corn and vegetable oils (rapeseed and sunflower) may also be used as biomass. Farmers should leave some crop residues on their fields so that the land remains fertile and to prevent soil erosion. Generally, a part of this residue may be collected from the field for renewable energy in a sustainable manner, e.g., plant stalks and straw from corn or other cereals crops and sugar cane. Other usable residues are also produced during food processing, e.g., corn cobs and residues of fruits (skins, pits) and vegetables, food processing residues, and orchard and vineyard prunings. Straw or stubble from barley, beans, oats, rice, rye, and wheat, stalks; residues from corn, cotton, sorghum, soybeans; orchard prunings, vegetable crop residues, vines and leaves that remain on the ground after harvesting are all biomass sources that can be used (Kim and Dale 2004).

The most important factor to be analyzed in the use of biomass from food crops is the expected competition for land between the food crops grown for energy production compared to those grown for food. The competition is also based on the interactions between the food production and increased demand of land, and the subsequent effects on the food prices and land rents. There are different models which are used in highlighting the significance of land availability and regional differences. It is necessary to complement this information with the estimated losses in arable land which occurs as a result of soil degradation and scarce water resources in terms of traditional agricultural systems. This should also be complemented because of the climate change that has the negative impacts on the agriculture and the suitability of land for the purpose of farming in the climate zones which are non-temperature.

Among different human alterations on the global environment, expansion of agricultural land is considered to be the most important factor. This has several adverse effects on ecosystems. Different, important criteria used to assess environmental sustainability of agricultural systems include pesticide load, soil quality, problems related to long-term sustainability, erosion, and salinization, nitrate leaching, water use and biodiversity (Matson et al., 1997). These criteria must be considered if crops or crop residues are also going to be used as a source of bioenergy. Even though there are many positive impacts of the green revolution on crop yields and food security which has helped relieve poverty for millions of people in last 50 years, but the green revolution has many adverse effects too which need to be understood. For 40 years, the green revolution left positive impacts; after that it started bringing in negative impact in many countries (Matson et al., 1997). Thus, the fact that whether it is possible to sustain a high intensity of agriculture is still not clear. It is expected that bio-energy can create different problems because of the increase in production techniques which occurs as a result of the increase in biomass demand. A land area for the bio-energy production has been dedicated which will be around almost 500 million ha by 2050–2100 (Berndes et al., 2003). This is one-third of the area which is currently used for the agricultural purposes.

The key factor in realizing the full potential of energy derived from agricultural residues is scale. Implementation of bioenergy systems depends either on the development of efficient, small scale conversion technologies for on-farm applications or locating larger, centralized combustion or anaerobic digestions plants in areas where sufficient feedstock supplies can be transported at a reasonable cost. Development of energy systems based on agricultural residues requires long-term research and development designed to harness the many benefits of bioenergy production independent of fluctuations in energy markets and prices (Helwig et al. 2002).

2.3.4 Manure

Where appropriate, i.e., when not used to fertilize agricultural fields, manure can be converted to electricity in biogas plants. Manure can readily be collected from confined animal feeding operations. Dried animal manure has been and still is used a great deal in some countries, e.g. India. Poultry litter (Priyardarsan et al. 2004), animal dung (Amon et al. 2007) and even human waste can be used in this process. For eastern Canada, manure production and the corresponding daily energetic values (in gigajoules) are summarized in (Helwig et al. 2002). Dairy, beef, swine, poultry, turkey, and sheep manures were compared and it was shown that by far the best energy yield was from swine and poultry manure. If human sewage is treated, it potentially also could be used.

2.3.5 Wood

The forest industry in Canada and other countries with large forest resources produce timber, wood chips and pulp (for paper, etc.) and is a major source of biomass (Bergman. and Zerbe 2008). For example, Canada has about 397 million ha of tree-covered land, of which 347.71 million ha is forest land boreal and mountain and west coast forests (Natural Resources Canada 2012). This is a decrease from 2002, when about 417 million ha were under forest cover (Natural Resources Canada 2003). The residues from harvesting a proportion of the forests and from the pulp and paper industries represent a large amount of biomass potentially available for collection and conversion into energy, though over the past decade that amount has decreased. The in-forest residue is potentially available to Canadian industry as a fuel source. Woody debris is what is left after removing those parts of the tree of commercial value (timber) during tree harvesting – tree tops, branches, small-diameter wood, stumps, dead wood and even misshapen whole trees – as well as undergrowth and low-value species may be used. Tree tops and limbs are scattered on the land where wood is loaded into trucks. Residual trees that have no commercial value and those that are unusable because they are imperfect, diseased or dead, can be used as a biomass energy source. However, the most commonly used form of woody biomass is sawdust and tree bark from sawmills, and pulp from pulp and paper mills. Shavings produced as a byproduct during manufacturing of wood products is another important form of biomass. Trees cut during regular forest or plantation thinning may be harvested. If these trees are removed periodically, the growth of the other trees improves many fold. The thinned trees have a small diameter and are likely to be rejected by the timber or paper industry. The number of trees with a small diameter is high so potentially a lot of biomass is obtained from them. Finally, short rotation trees can be harvested if the conditions are right. These short rotation trees, e.g. aspens and poplars in Canada, grow quickly compared to other trees. They are planted every twenty years and are harvested more often, i.e., every three to five years because they regenerate very quickly by coppicing. These short rotations plants store more carbon than long rotation trees. Forest management must ensure that proper policy is implemented so that the short rotation plants are used efficiently and sustainably. Like crops, it is equally important to leave a certain fraction of tree residue on the site because it improves land fertility. If in-forest biomass residue is used as a primary fuel, it could meet the energy demand of Canada. But the cost of this fuel is higher compared to other sources of fuel.

Energy associated with forest biomass could be very profitable for new industries, because any cellulosic material abandoned today (branches, bark, logs, stumps, twisted wood, and wood diseased, infested by insects or damaged by fire) would be transformed in value-added energy products. The use of forest biomass for energy also offers the opportunity to get rid of lower quality stands and replace them with productive stands made from more valuable species. According to estimates, some areas (like British Columbia) enough wood waste exists to produce solid and liquid fuels that could replace much of the current oil consumption, once profitable energy conversion technologies are developed. (Zhu et al. 2010) discuss pretreatment of woody biomass for fuel production

In parts of Canada, such as the Aspen Parklands north of the prairies, establishing energy plantations is necessary if we want to obtain the necessary biomass to replace oil significantly. Marginal agricultural land unsuitable for cultivation and non-agricultural land (e.g., wetlands) would be used to a culture with intensive forest cutting rotation periods of less than 10 years. Currently, the tree species tested are mostly hybrids of poplar, but also larch, green ash, willow, alder and silver maple. With the selection of species, origin and phenotype, and thanks to cloning, it is possible to considerably increase the yield and disease resistance and frost.

The first step would ensure the use of all logging residues and wood processing products from the forest industry. These materials are used increasingly as substitutes for fossil fuels. The economics are generally favorable because the materials are concentrated and the costs of handling and transportation are part of the main forest product exploitation from which they come. The second phase involves the use of wood waste and residues that are currently unused by logging, as occurs, for example, in Tanzania (Misana 2008).

The third step would be to seriously consider the establishment of plantations fast-growing tree hybrids. More than 20% of solid waste disposed in Canadian landfills is wood waste.

Sources of urban wooden waste include construction materials, discarded pallets and drayage, and wood waste from the furniture industry.

More than 50% of Canadian biomass fuel is attributed to wood processing residues, which include wood trimmings, end cuts, barks, saw dust, rejected lumber and round offs. Sawmills use almost 50% of the biomass in Canada but a portion of the woody biomass is used by many other industries as well. Pulp, wood chips, fiberboards and decorative bark are also used in many parts of Canada. About 20% of saw logs biomass content brought to sawmills in Canada has no value and needs disposal. Much of this biomass content is burned in the biomass power plants. The USA also produces a lot of wood waste and residues (Fehrs 1999).

Compared to agricultural biomass, which is usually available only once a year, wood can be cut throughout the year. The annual yield of the forest is approximately 20 times that of agricultural land. Nevertheless, agricultural biomass can be obtained locally, e.g., from family farms. Forestry biomass is a sustainable alternative to agricultural biomass because it does compete with crops used for food and can be planted on a large scale. The land occupied by forest worldwide is more than enough to meet current and future energy requirements of the world. However, it is important that sustainability in woody biomass harvesting is maintained (Janowiak and Webster 2010).

2.3.6 Municipal and industrial waste

An important source of biomass includes clean industrial and municipal waste (EPA 2003), potentially including human waste and dead animals. This type of biomass results from routine human activity and comes many forms, e.g., garbage such as waste paper, yard waste or food residues, urban wood waste including garden tree and hedge trimmings and unused construction wood. Plant fibers are potentially useful source of biomass (Reddy and Yang 2005). Industrial and household waste converted to biofuels (ethanol, methane, etc.) rather than being dumped in landfills is a good option if the technology exists. If energy prices were to increase significantly biomass conversion technologies could become more commonplace.

3 PROCCESING BIOMASS TO ENERGY

The feasibility of using biomass depends on two main issues: the efficient production of biomass from different sources (discussed above) and the efficient conversion of biomass into usable energy, discussed here. Whatever the biomass source, humans must convert it into energy for it to be useful. Energy may occur in three ways (in addition to eating biomass like grains, nuts, fruits, vegetables, animal products to keep themselves alive).

3.1 Solid fuel combustion

Biomass can be used directly as fuel by burning it. Burning is widely used because of its ease of availability and minimum risk. Combustion is chemical conversion (oxidation) of complex carbon molecules to simpler molecules by the action of heat alone, with a lot of heat being released in the process. This heat can be converted into mechanical power or electricity (McKendry, 2002). This is the simplest and by far the oldest technology to obtain useful energy (heat for warmth and for cooking). Since the industrial revolution biomass is also burned to produce electricity. Forest and agricultural wastes are burned in a combustor to boil water and produce steam which, under pressure drives a steam turbine that coverts mechanical energy into electricity through a generator. In this direct combustion process, large amounts of ash is produced which affects the performance of the combustion chamber and reduces its efficiency, so only few types of biomass are used for this combustion process (Mwandosya et al. 2007). The heat or energy produced through combustion process cannot be stored for future use and hence used then and there. The efficiency level of those plants is only about 25%. The cost of acquiring raw material is also not very high because the raw material is mainly based on forest, agricultural or pulp and paper industry waste.

Burning biomass may be done either in dedicated power plants or co-firing biomass with coal. In the latter, about 20% of biomass feedstock material along with 80% of coal is used in this process. Usually industries use co- firing because it's more economical and generates more electrical energy compared to other methods of power generation. This is a rapid process and releases energy quickly, as heat. In pyrolysis, biomass material is converted into gas or charcoal which is then oxidized to produced heat or energy. In pyrolysis, basically thermal decomposition is done in the absence of oxygen so the biomass is only partially oxidized, producing charcoal which can be stored and burned later

Today in the USA biomass represents the single largest source of electricity from non-hydro renewable resources, fueling more than 9,700 MW of generating capacity in the US alone (EPRI 2007). Most of this biomass comes from forest products and agricultural residues, with the raw material fired directly in a power plant boiler either by itself or as a supplement to fossil fuels, particularly coal. The use of municipal solid waste for power generation is also growing. Heat or electricity is produced using technologies that continue to improve in efficiency (URT 2001, McKendry 2002). In addition, biomass provides the only renewable alternative for producing liquid transportation fuel, a prospect that has become the focus of much research. The technology for biomass conversion into liquid biofuel or biogas released from fermentation or decay in landfills or fermentation chambers is progressing rapidly. After direct solar energy and hydroelectricity, biomass is the most important renewable energy source and supplies almost

42% of the world's energy sources (Union of Concerned Scientists 2012) and, in Canada its use combines the oldest and newest of energy technologies.

Biomass is often classified as either "clean" or "dirty", referring to the contamination of woody material with other wastes or substances. Municipal solid waste (MSW) and construction and demolition (C&D) waste streams regularly include contaminated biomass. Common contaminants are from paints, stains, soils, and chemical spills. While contaminated biomass should not be considered unusable, the market demand and technology (including environmental controls) needed to utilize "dirty" biomass supplies is likely to be different. In some situations, MSW and C&D waste streams can be sorted to remove "clean" biomass from the contaminated Supply (Fallon and Breger 2002).

In some countries, e.g., Canada, waste generated by saw mills and pulp mills is burned to generate steam for use by the mills themselves. Timber companies have also started to burn sawdust and lumber scrap for generating power. Using lumber scrap and sawdust reduces waste disposal cost and lowers utility bills. Half of the paper industry energy is derived from burning biomass because it is cost effective. Trash is also burned to produce useful energy. Burning about 2000 pounds of trash can produce as much energy as 500 pounds of coal. The natural organic waste component of garbage (i.e., not plastics, metal and glass) can be burned in waste-to-energy power plants to produce natural gas. These plants convert garbage into useful forms of energy just as coal fired plants do but the only difference is that their boilers are fueled using the garbage and not coal.

Burning biomass has serious consequences for the environment. When burned biomass adds CO_2 to the atmosphere, although this can be partly offset by planting new forests or crops that remove CO_2 from the atmosphere. The following two methods of converting biomass to energy are less environmentally damaging. While it is possible to use all types of biomass, combustion is preferable when biomass is more than 50% dry. High-moisture biomass is better suited for biological conversion processes. Net bio-energy conversion efficiencies for biomass combustion power plants range from 20–40%. Higher efficiencies are obtained with combined heat and power (CHP) facilities and with large size power-only systems (over 100 MW), or when the biomass is co-fired with coal in power plants (McKendry, 2002). Co-firing biomass with coal is a straightforward and inexpensive way to diversify the fuel supply, reduce coal plant air emissions (NOx, SO2, CO2), divert biomass from landfills, and stimulate the biomass power industry (Hughes, 2000). Moreover, biomass is the only renewable energy technology that can directly displace coal. Given the dominance of coal based power plants in the USA, electricity production, co-firing with biomass fuel is the most economical way to reduce greenhouse gas emissions. Possible biomass fuel for co-firing includes wood waste, short-rotation woody crops, switch grass, alfalfa stems, various types of manure, landfill gas, and wastewater treatment gas (Tillman, 2000). In addition, agricultural residues such as straw can also be used for co-firing.

3.2 Biological decomposition (fermentation):

Apart from burning the most commonly used method of energy production is converting biomass into liquid fuels (ethanol) and capturing methane gas from landfills or animal waste (manure) processing plants. Biogas production from agricultural biomass is of growing importance as it offers considerable environmental benefits (Chynoweth 2004). Biomass is also extensively used to produce biofuels. Trees utilize the energy from the sun and carbon dioxide from the environment in the process of photosynthesis to produce carbohydrates. When plants die, the process of decay releases the energy stored in carbohydrates and discharges carbon dioxide back into the atmosphere. The reaction that converts biomass into glucose is given by equation: $6H_2O + 6CO_2 + \text{Radiant Energy} \longrightarrow C_6H_{12}O_6 + 6O_2$.

Anaerobic digestion, direct combustion and gasification-combustion technologies may be used depending on the biomass source. In thermo chemical conversion, plant matter is heated so to change it into liquid (ethanol) or gas (methane). Biological and chemical decomposition are processes that release energy slowly through natural decay, fermentation or digestion. Yeasts, enzymes and bacteria are used to break down the biomass through fermentation. The breakdown products are methane and ethanol which are further processed to produce electricity or transportation fuels, respectively.

The chemical process of transesterification can be used to produce biodiesel from animal and plant waste. Chemical extraction technologies can be used to produce biodiesel from the vegetable oil. In this chemical process, liquid fuel is produced from canola or soybean oil. Starch and sugar crops in Canada can be used to produce ethanol directly.

Fermentation is done with materials that can decompose such as manure and crop residues in an airtight tank, called a digester, with a steel or brick lining and in which fermentation occurs in the absence of oxygen. Biogas digesters are economical and can be built as community sized or family sized units without much difficulty. Developing countries where energy shortage is a growing problem can make use of biogas digesters to produce energy economically instead of using wood (and causing deforestation) to meet their cooking and heating requirements. In fermentation, yeasts are used to ferment plant sugars, transforming them into ethanol and other liquids, e.g., butyric acid and acetone, and various gases, especially methane. Two thirds of the energy from large animal manure and poultry waste produce methane rich gas could be recovered in the form of biogas or liquid (ethanol) by fermentation. The use of biogas or liquid fuel such as ethanol has the advantage that the gas has a much lower proportion of sulfur compounds (that cause of acid rain), compared to direct combustion of biomass. Gas produced by anaerobic digestion of municipal solid waste in landfills is increasingly used today.

Burning biogas is much less polluting for the environment than burning biomass because no smoke is produced. Dairy farms use biogas for energy, which can be used for bio-power generation in place of fossil natural gas. The biogas can also be cleaned by farmers themselves and injected into natural gas pipelines that carry it to power plants and burned to drive steam turbines that produce electricity.

Another possibility is to digest or ferment biomass using anaerobic bacteria. Fungi and bacteria convert cellulose into sugar in dead plants. In animals the fats and proteins are converted into products the fungi and bacteria can use. In both cases the plants and animals rot or decay until nothing but bone is left. This is a slow process but an important byproduct, methane gas, is produced and can be collected from, e.g., landfills, and purified for use as fuel. Methane collected from landfills and burned to convert it to carbon dioxide instead of releasing it in the air also helps protect the environment. .For example, the East Kentucky Power Cooperative collects methane from five landfills and this generates enough energy to supply to about 8000 homes. Unfortunately, collection of this gas is very costly as compared to natural gas..

Ethanol is becoming a very important fuel source in many countries, with a total world production of 88.7 billion litters in 2011 (Licht 2011). The ethanol is fermented from two primary sources: grains (Canada, USA, China, Scandinavia, England, Germany, France, and Spain) and sugar from sugar cane or sugar beet (Central and South America, Italy, Switzerland, Austria, Eastern Europe, India, Southeast Asia and Australia).

The two biggest ethanol producers and users are USA with 42% of world use and Brazil with 32% (Anonymous 2008). Other countries are China (Tan et al. 2010), India (Datta 2008), Argentina (Idígoras and Papendieck 2011), and Australia (Darby, 2012).

Current research focuses on the conversion of biomass to alcohol to supplement or replace gasoline and diesel fuel. Biofuels are the most immediate, practical solution for reducing dependence on fossil hydrocarbons, but current biofuels (alcohols and biodiesels) require significant downstream processing and are not fully compatible with modern, mass-market internal combustion engines. The production of ethanol from cellulose is currently performed in two steps: transformation of the cellulose into sugars followed by transformation of sugars into ethanol by fermentation. With new strains of genetically modified bacteria, it is now possible to consider combining these two transformations for producing alcohol from cellulose in one step.

The ideal biofuels are structurally and chemically identical to the fossil fuels they seek to replace (i.e., aliphatic *n*- and *iso*-alkanes and -alkenes of various chain lengths). Production of such petroleum-replica hydrocarbons in *Escherichia coli* is being investigated. Rather than simply reconstituting existing metabolic routes to alkane production found in nature, recent research demonstrates the ability to design and implement artificial molecular pathways for the production of renewable, industrially relevant fuel molecules (Howard, et al. 2013).

Other liquid forms of biomass energy include methanol (wood alcohol) and vegetable oils. The addition of methanol or ethanol to gasoline results in a product called "gasohol". As a product of the distillation of wood and forest waste, methanol can be considered as an alternative fuel for transportation and industry, at prices that can compete with fuels derived from bitumen and coal liquefaction. Ethanol is also a valuable fuel, but its production costs are higher when food resources such as corn and wheat are used. In contrast, when ethanol is produced from food waste the costs can compete with those of methanol and gasoline.

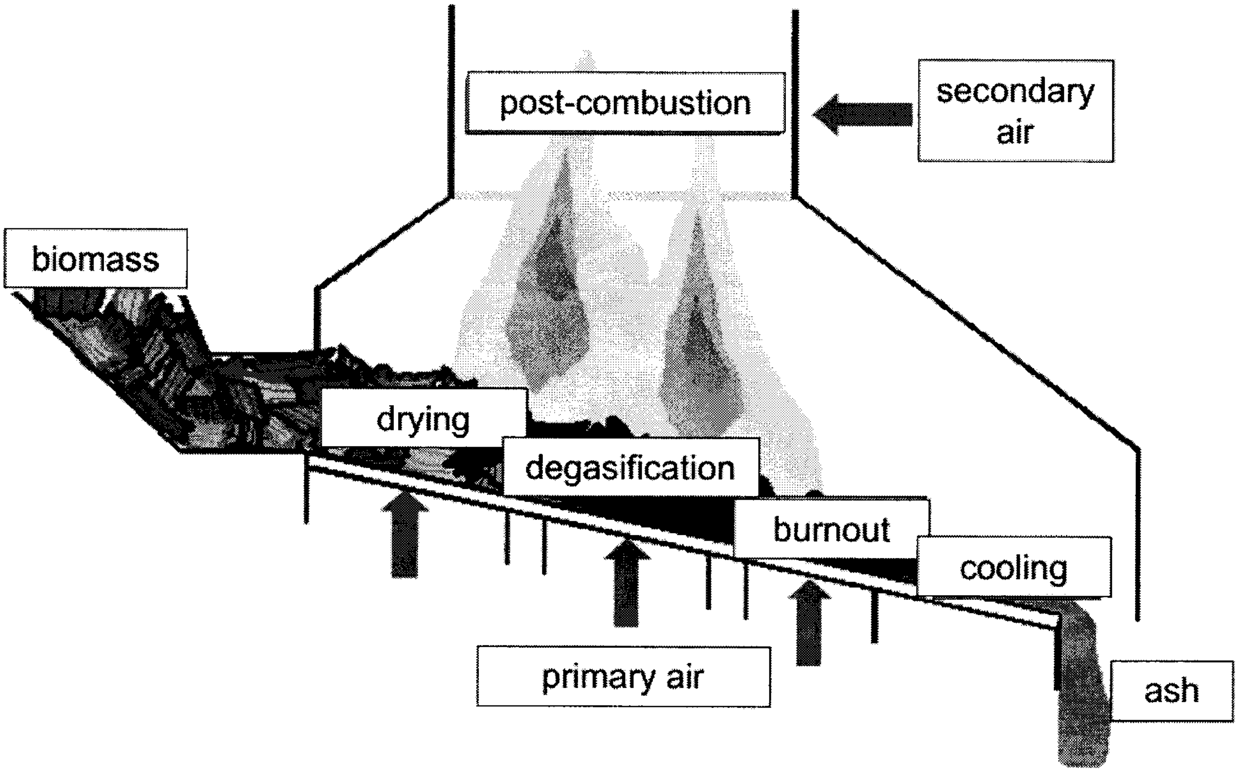
3.3 Gasification

This is the most adopted technology to convert raw biomass material into hot gases (NBS 2002). Gasification converts biomass into gases like CO, CO2, nitrogen, oxygen, and methane. The gasification of animal waste or residues the food industry can reduce pollution, minimize the waste disposal problem, and provide energy. A gasifier is the chamber where gasification takes place. Gasifiers are of different types: updraft, downdraft, cross draft, and fluidized bed gasifiers. In the gasification process, the matter flows in gasifier through different stages: combustion, reduction, and paralysis, In the paralysis, dried biomass is burned to produce volatile gases such as carbon monoxide, methane, and hydrogen at around 700°C. In combustion, activated carbon reacts with water vapor and carbon dioxide to form gases such as hydrogen and carbon oxide. In reduction, the main reaction is CO being formed from CO2 molecules and charcoal. The combination of carbon monoxide and hydrogen is known as synthetic or producer gas and is the final output of the gasifier and input to a gas turbine to produce electricity.

Gasification has several advantages over direct combustion. First, the gasification process is easy and methane is a byproduct which can be used to generate energy. Second, producer gas consists of much fewer impurities and thus fewer pollutants will be released when burned. Third, it is more efficient compared to solid fuel combustion (NBS 2002). The Energy Information

Agency projects a significant increase in generation of electricity from municipal waste and landfill gas to about 0.5% of U.S. electricity consumption (EIA, 2004, BR&Di 2008).

A promising technology development currently at the demonstration stage is the biomass integrated gasification/combined cycle (BIG/CC), where a gas turbine converts gaseous fuel to electricity with a high conversion efficiency reaching 40–50% of the heating value of the incoming gas (McKendry, 2002). An important advantage of gasification is the ability to work with a wider variety of feedstocks such as high alkali fuels that are problematic with direct combustion. High alkali fuels such as switch grass, straw, and other agricultural residues often cause corrosion, but the gasification systems can easily remove the alkalis from the fuel gas before it is burned. High silica, also a problem with grasses, can result in slagging in the reactor.



4. RESEARCH PROBLEMS AND METHODOLOGY

The main problems of the development of biomass energy are to take fairly high cost of new facilities and need to make the industry fully renewable. Government policy and increased prices of traditional energy sources could solve the cost problem. The problems of reforestation, land use and water, soil quality and sustainability (Burger 2002), erosion and pollution must not be neglected. Energy production, added to production of wood and paper, may endanger the renewal of forest resources, already compromised by past practices of the industry. Biomass energy should be a product grown and not extracted. Otherwise, biomass may join the ranks of coal, oil and natural gas to become another source of non-renewable energy. Managing forest ecosystems for sustainable biomass production is being implemented in various places (Röser et al. 2008). The problem is basically finding a way not to compromise food needs and environmental quality while still being able to produce biofuels from biomass (Tilman, 2009).

A lot of research has been done on residue management of crops and there are huge markets for industrial and crop wastes. It is common practice that a part of residue is left on the crop by farmers to enhance the land productivity and fertility. But conservation plans are also required for federal crop programs. There are fewer markets for forestry residues and best management practice guidelines are needed to address issues like saw log and pulpwood markets and water quality.

Proper certification, management plans and implementing of best management practices are necessary to ensure biomass sustainability. Practical and effective sustainability provisions have been developed by forest owner association and forest ecologists to ensure sustainability of woody biomass harvest. In order to avoid the negative effects of biomass removals, different states in the USA like Missouri, Minnesota, Pennsylvania, Maine and Wisconsin have developed biomass harvesting guidelines called State Based Biomass Best Management Practices. Biomass guidelines are under development in other regions as well. These guidelines are practical enough to be implemented by farmers and loggers.

Biomass harvest sustainability can be verified using third party forest certification as well. In the USA more than 275 millions of acres of private and industrial homeland have been certified by the forest stewardship council and tree farm. Professional foresters have written forest management plans which, when properly implemented, minimize the impact of biomass removal. Although many small foresters have developed their own management plans, forest management associations encourage forest owners to write their own management plans. More money is generated by those forest owners who have their own, personalized forest management plans.

Care should also be taken to ensure that the land water quality, biodiversity, wildlife habitat and soil productivity (Doran 2002) are not affected. Sustainability indicators and standards have been developed for Canadian forests (Natural Resources Canada 2012). The standards should be determined for local conditions in different countries. Implementation of sustainability standards ensure that nutrients lost during biomass harvest are replenished in a timely manner so soil productivity is not affected. Biodiversity should be protected by ensuring that sustainability standards are implemented rigorously some percentage of native ecosystems must be retained untouched (not harvested for biomass) to protect the native flora and fauna. Strategies should be implemented to regrow the forest again so that it may be used as a future biomass energy resource.

Harvesting Limitation/production volume (trees and agricultural crops):

If crop residues and not wood from forests is the only source of biomass in a region then an important concern is that the crop used as a biomass energy source is limited, i.e., it is seasonal. Agricultural crops can be harvested only once a year, at least in countries at higher latitudes, so a problem with constant supply exists. Alternative forms of biomass must then be used to ensure a year-round fuel supply efficient and cost effective use of biomass energy plants.

If wood is the principal source of biomass then deforestation may be the most important problem. If deforestation exceeds reforestation the use of woody biomass is not sustainable and there are other bad consequences. For example, in India and Nepal, deforestation leads to more contaminated ground water, irreversible erosion, and more earthquakes (Hobley 2006). Harvesting of trees must be done to an extent that ensures that the land's ability to meet future needs is not depleted. Furthermore, it also ensures that sustainability indicators are not degraded in any way and impact on environment is minimal. But it is not possible to plant trees on such a wide scale for many reasons. For example, the present energy needs of the US may require tree planting on about one million square miles and it is not economically feasible to plant trees on such a wide scale. If biomass use from logging of tropical forests occurs the logging must be selective to conserve carbon stocks or else not only is there increased emissions of greenhouse gases but loss of biodiversity will occur (Putz et al. 2012).

As a lot of space is needed for biomass cultivation, this potentially reduces the available space to grow food crops. Hence, the land area for food crops is reduced and limits their production. This is obviously harmful for countries in which food shortages are common. This food versus fuel debate is an ongoing discussion topic.

5. BIOMASS AND OTHER SOURCES

This section compares biomass energy with other forms of energy: 1) fossil fuels energy 2) nuclear energy, 3) wind energy, 4) solar energy, 5) hydroelectric energy, and 6) geothermal energy.

5.1 Fossil fuel energy

There are many advantages of using biomass energy sources compared to fossil fuel sources.1) Biomass energy is a renewable energy source whereas fossil are not renewable and are depleted over time, although new fossil fuel sources are constantly being discovered but the cost of their discovery and capture often becomes greater. The net carbon dioxide emission due to use of biomass fuels is negligible whereas the emission from fossils is high. The net carbon dioxide emission into the environment is zero because the biomass sources absorb carbon dioxide from the environment when they are regrown and emits back when converted into energy. Hence, the total content of carbon dioxide in the environment is same. If a biomass energy source is used, methane, other, hydrocarbon emissions, and sulfate emissions will be minimized. On the contrary, due to high emission of sulfate and carbon dioxide, the environment is polluted due to fossils.

2) If local biomass sources are used to produce biofuel, there is less or no need to import foreign oil or gas and if biomass is derived from household and industrial waste this is recycled in a useful manner instead of simply being buried in landfills.

3) As better technologies develop the use of biomass for energy production will increase whereas that of fossil fuel may decrease as the cost of obtaining it increases. Statistics suggest that 80% of vehicles use fossil fuels and only 20% use biofuels (ethanol). The total energy

obtained from biomass sources in US accounts for about 3% of the total energy according to the recent statistics. This percentage will increase because biomass sources have many benefits and commercial production of biomass is higher as compared to fossil fuels.

4) The initial cost of biomass energy production facilities is relatively high compared to facilities that burn fossil fuel but once the biomass plants are installed; biomass energy can be produced easily and more cheaply.

5.2 Nuclear energy

This section explains the positive and negative aspects of using nuclear energy as compared to biomass energy. Positive aspects of nuclear energy are: it does not release gases such as NO_x, or SO_2 that cause acid rain, and there are no emissions of particulate carbon or CO_2 and it is produced continuously so nuclear energy is reliable. Nuclear waste is compact and so does not require much space to store it safely after use. Apart from accidents in which radioactive material escapes into the environment, nuclear energy does relatively little harm the environment, mostly as thermal pollution of air and water. Once the nuclear reactors and containment facilities are build nuclear energy production is cheap from then on. Negative aspects of nuclear energy are that upstream costs such as mining and processing uranium, uranium enrichment and fuel rod fabrication are very high. There are also high downstream costs which are required for permanently safe nuclear waste storage. On both the upstream and the downstream sides, concrete, steel and other materials are needed and production of these materials result in indirect CO_2 production

The negative aspects include nuclear energy requires huge capital investment to produce the energy and after the fuel rods are spent in safely storing radioactive waste. Finally, there is always a fear of nuclear explosion if care not taken to prevent it. However, if Thorium is used it may be a lot safer.

The energy produced by nuclear plants is very high. About one pellet of uranium can produce energy equivalent to energy produced by the 17,000 cubic feet of natural gas, 1,780 pounds of coal or 149 gallons of oil.

If its negative aspects are tackled then nuclear energy from uranium can be used as an effective form of energy that could easily fulfill the energy requirements for the world. . In conclusion, nuclear energy is more beneficial as compared to biomass. The nuclear plants produce energy more quickly as compared to the biomass sources.

5.3 Wind Energy

Wind turbines use the energy from the wind to rotate turbine blades and produce mechanical power. A wind turbine or a windmill transforms the kinetic energy of wind or the masses of air generated by uneven heating by the sun of the earth's surface into electrical power. Wind turbines are installed and connected to the electrical grid in the form of multiple installations known as "wind farms". They are installed in places where winds blow at a speed above 5.5 meters per second; it may be on land or offshore. The latter have advantages as offshore winds are more stable and reach higher speeds and wind turbines located near the sea shore or offshore don't add to environmental noise, don't occupy space needed for other purposes.

Wind power has undergone considerable development, gaining an important share of the market regardless of the fact that between the mid 2000s and 2008 wind power represented only 0.2 percent of global energy production. From 2006 to 2008, the global cumulative installed capacity grew by 1,880%t: in 2006, the global cumulative installed capacity reached 6,100 MW, where as in 2008 it reached 120,791 MW. United States has the highest installed capacity with 25,170 MW, followed by Germany with 23,903 MW, Spain with 16,754 MW, China with 12,210 MW, and India with 9,645 MW. They together produce 72.6% of the world's total installed capacity.

Even though wind power is regarded, along with biomass, as the chief substitute to fossil fuels, wind farms are targeted lately by NIMBY protests (the acronym for "Not in My Back Yard"), which is normally used to specify public protests aimed against construction of infrastructures of public interest. The most famous cases include the wind farms constructions in Nantucket Sound in Massachusetts and in County St. Lucie in Florida. Studies carried out so far, however, have somewhat reduced alarm by some in the environmentalist movement. Wind farm concerns include land seizure, noise pollution, electromagnetic wave production, visual impact on the landscape, interference with bird flight (most famous case is that of birds of prey killed by wind turbines in Altamont Pass, California), and concerns over sea life (with off-shore wind farms).

Disadvantages of wind power are: 1) a high cost price for building and installing wind turbines, 2) in the absence of wind no electricity is produced, i.e., erratic energy production results. This limitation can be overcome by storing the energy for times when there is no wind, but storage facilities are expensive, 3) relatively few suitable places to build wind farms because their placement in many areas affects the scenic beauty of those areas, e.g., owners of coastal homes have complained that due to the wind turbines, they can't enjoy the scenery. Thus, it is very important to build wind farms after careful planning, 4) noise production as persistent, low frequency vibrations that are disturbing to some people. Animals may also be affected by this low persistent noise. 5) Flying organisms are killed when they are hit by the moving rotor blades.

Advantages are 1) low operating costs – wind is the energy source with the lowest externalities (costs resulting from the utilization of the plants), according to the G8 Task Force for Renewable Energy, 2) the need to purchase fossil fuels to produce power is eliminated, 3) no pollutants (greenhouse gases, radiation, and particulate matter) are generated.

With the support of environmentalist associations, "small wind systems" have begun rise in the last few years. Less than 30 meters turbines are used in these new power generating systems. As compared to the large-scale wind farms, the "small wind system" is simpler to assimilate into the landscape. From the early 2000s, these plants, supported by the British Wind Energy Association, are commonly found in Great Britain. These farms may make it likely to create a self-sufficient network: a string of bioenergetics firms and districts that use a fraction of the energy produced and trade a fraction on the network, with investment returns possible in just a few years.

Just like biomass energy, wind energy does not pollute the environment and does not emit gases which add to global warming. This is one of the most important benefits of wind energy that the overall environment stays clean and healthy. The equipment used for wind energy is costly but it does not add to pollution. Due to high demand, wind energy cost is same as gas powered energy. Unlike other renewable energy sources which require additional fuel so that they can be converted into usable energy, no fuel is required by wind turbines. Thus, wind energy is more beneficial compared to biomass energy sources which require fuel. Using wind energy, electricity can be produced at a much cheaper and economic rate than by burning biomass or fossil fuels

The current cost associated with wind energy is high but it will come down when demand increases. Wind energy can be used for small and large scale purpose. Industries can customize their wind energy turbine separately and meet their energy requirements.

5.4 Solar Energy

Energy from the sun can be utilized to generate power with the use of different solar collectors. The stored energy in the organic matter (biomass) can be extracted in various ways to produce heat, bio-fuels, or power. The energy radiated by the sun is solar energy. It is used to produce electrical power or heat. There are currently three main technologies for converting solar energy to electricity or heat: photovoltaic cells, solar thermodynamic systems, and solar thermal systems. Photovoltaic cells use the photovoltaic effect; which means to produce electrical power when sun rays directly hit the cells. Photovoltaic cells are the foundation of the process of transforming solar radiation into electrical power: Assembled cells make a photovoltaic module, which is usually made up of 36 cells, each of them producing around 40 to 50 watts of power. When a number of modules are brought together as a single structure, it constitutes the solar photovoltaic panel.

In contrast, solar thermodynamic systems use sunlight to produce electricity from the energy released by heated fluids at a high temperature (about 400° C). It is the most competitive solar system as it can be put into operation quickly and is the most flexible.

To date, there are three kinds of solar thermodynamic systems: parabolic dish, parabolic trough, and solar tower. The parabolic dishes concentrate solar energy on a tube which is placed in the focal line of the collector. Carrier fluid runs inside the tube, which gets heated and transfers its heat energy to a heat exchanger. On a receiving system placed at the focal point of the dish, the parabolic trough uses concave, dish-shaped reflecting parabolic mirrors to concentrate light. A series of mirrors are used in solar towers that follow the movement of the sun and reflect the sun's light onto a heat exchanger placed on top of a tower. Thermodynamic solar technologies have been industrialized mainly in California, where solar power plants were created with a capacity of 350 MW. Recently,, a 64-MW thermodynamic solar power plant has been built in Nevada, and two additional solar power plants are being researched in the state of Florida and in Spain.

Solar thermal systems are engaged for heating water destined for air-operating domestic heating systems. Solar thermal systems absorb heat through a solar manifold, transferring it to a collecting or using place by means of a fluid carrier (mostly water or air). These days, solar energy represents about 0.16% of global energy production.

Among the different solar technologies, photovoltaic system has gained the most credibility. In the USA the global installed capacity of photovoltaic systems has risen from 1,200 MW in 2000 to 9,200 MW in 2007—an increase of 66.7%. In 2007, 85% of photovoltaic plants could be found in Europe, North America, and the Pacific; 73% of the market was concentrated in Europe, where the photovoltaic system has been promoted by German and Spanish investment. The country with the highest installed capacity is Germany, with 3,800 MW, followed by Japan with 1,935 MW, the United States with 814 MW, and Spain with 632 MW.

According to the European Photovoltaic Industry Association, the photovoltaic market will be dominated by Asia, Africa, and South-Central America in the next few decades. The developing countries will be able not only to catch up but also to become the exemplary market for photovoltaic energy.

China in particular will take up the role of leader, with investments that will double the European. Even today, there is a city in China, Rizhao, which can be defined as "a solar energy city." In Rizhao, solar thermal systems provide hot water to 99% of the families who reside in the central districts and to 30% of those residing in the outskirts. In total, there are 500, 000 square meters of solar collectors in Rizhao.

The energy source with the least negative effects from an environmental point of view is solar energy. No risk to natural environment or to human health has been observed in their life cycle of 25–30 years because, e.g., no carbon dioxide or other gases are emitted during its production.

The return on solar energy is very high and the payback period is quick. Solar energy can fulfill all the energy requirements of any household. If energy produced is higher than that required, the government can buy the energy back when it is fed back into the electricity grid. Net metering is the process in which the government or the utility company buys the excess of energy.

Since solar rays are free and are not subjected to demand and supply, the cost remains unaffected. It is renewable and unlimited. Solar energy does not cause smog and acid rain like fossils or biomass. The harmful green house gases are reduced manifold if energy requirement is fulfilled using solar energy. The solar energy plant works on its own and does not require any gas or power grid. The dependence on foreign sources can also be reduced if energy is produced using solar plants. It is sustainable form of energy.

The negative aspects of using solar energy include high initial cost of solar plant. The seizure of land in case of solar plants and alteration of the urban landscape, where photovoltaic cells are placed on roofs or facades of residential building, are the only negative aspects regarding their use. The major environmental detriment appears during the production of panels when toxic substances such as silane, phosphate, and cadmium are employed. In addition, panels produce a special type of waste, the disposal of which necessitates the recovery of the above-mentioned toxic metals.

If the air is polluted or the sky is cloudy, the solar energy production is highly affected. Proper sunlight is required for production of solar energy. Due to no sunlight at night or short day length at high latitudes there can be no production of solar energy. Solar plants are best used to meet the requirements of individual households..

5.5 Hydro Energy

Hydro or hydroelectric energy is the energy generated through water as the name suggests. Hydro power uses the energy of the water flow to produce electricity. Turbines convert the hydraulic energy into mechanical energy and thereby electricity through a generator. The principal source of renewable energy today is hydroelectric energy. It represents 2.15% of the total global production of energy. The development of new large-scale hydroelectric plants today requires infrastructure (dams, reservoirs, catchment drains) which have a considerable environmental impact because they seriously alter the landscape, impair the balance of local ecosystems, and diminish the volume of water available for uses other than energy production but at least hydro energy itself produce no polluting emissions. Due to these reasons, it seems more appropriate to develop hydroelectric plants with less than 10 megawatts of power production. Minor streams or river waterfalls are used to produce energy in these small plants with relatively low environmental impact. Such small hydroelectric plants creates very modest environmental and technical problems, chiefly where the construction of dams is

Some countries are also experimenting with new technologies that use sea water to produce energy. Experiments are also being conducted to produce energy from tidal power – the energy potential of waves in the United Kingdom, Norway, Japan and France and from the temperature difference that exists between deep and surface waters in United States.

There are several advantages of using hydro energy over biomass energy. Hydro energy does not require any additional fuel for power generation. Hydro power plants are very economical as its operating cost is very low and does not require frequent maintenance. Hydro power plants have long life – they can easily last up to 100 years. A typical hydro power plant breaks even in 10 years. The hydro power plant does not spoil the environment because there is no green houses gases emission so the air remains clean. Hydroelectricity can be produced both at small and large scales: from 1 MW to 10,000 MW and hence are useful for both industries and homes.

As compared to wind and solar energy, the reliability factor is higher for hydro power plants but lower compared to nuclear and coal base. The power generated from hydropower can be easily predicted and steps taken to meet future demand. When water flow is low, as in summer or the dry season hydro power plants can still work well even at 60%of the load.

The following are the negative aspects of using hydropower. Dams occupy lot of space and their construction affects people living in the area and especially downstream because the newly damed river no longer carries silt during high water (spring runoff) so fertility of farmland down steam is badly affected. Ecological affects include elimination of wildlife habitat. Large dams may increase the chance of earthquakes as evident from examples in China (Three-Gorge dam) and India (Uttarakhand dam). Siltation is another disadvantage of building dams. If the dam is not built properly, it can fail and result in huge floods thereby destroying people and property, e.g., the Banqiao Dam failure in Southern China directly resulted in the deaths of 26,000 people and another 145,000 from epidemics.

Dams cannot be just built anywhere but only in specific areas having particular characteristics, the most important of which is constant, reliable source of water. Dams cannot be built near farms or populated area because of the potential of floods if the dam breaks. Finally, dams take lot of time to build and cost a lot.

Overall, the positive aspects of using hydro energy outweigh the negative aspects.

5.6 Geothermal Power

Geothermal power uses the natural sources of heat inside the Earth to produce heat or electricity. Energy is generated by a physical process called geothermic energy. As one goes towards the centre of the earth temperature rises by 30°C every 1000 meters of depth. About 0.065 watts per square meter can be generated by heat rising to the Earth's surface. Geothermal plants are developed by drilling deep into the earth and capturing steam under pressure formed by the earth's heat in pipes as it comes to the surface. The steam is transmitted into turbine, where, by means of a driving shaft, it is turned into mechanical energy and then electrical power by an alternator. Hot water is similarly captured where the required temperature does not reach high enough temperatures to produce steam. The heat produced is used, e.g., in district heating plants or by agriculture for heating greenhouses. About 0.41% of the total global energy production is geothermal energy. Major users of geothermal energy include Iceland, Italy, the United States, Costa Rica, New Zealand, Japan, Kenya, and Ethiopia.

Geothermal energy is environment friendly energy and does not add significantly to environmental pollution. It also does not have harmful effects on the environment because there is a minimal or low green house gas emission of about 0.2 kg of carbon dioxide per kilowatt hour. Other emissions are hydrogen sulfide, ammonia, mercury, and radon, which are the main concern.

Geothermal energy does not any additional fuel cost; it produces a uniform amount of energy reliably year round, and has no limits in terms of production.

The negative aspects of geothermal energy are the limited locations it can be captured easily and cheaply. It takes about seven years to develop a geothermal energy field require a lot of financing and thus investors resists in investing here. There are only few geothermal fields' developers available. In summary, when compared to other sources of alternative energy like hydro or solar power, geothermal energy has less potential in many areas than biomass energy but it may more potential that wind.

In the next chapter four case studies with analysis consider it as methodology at this research. These case studies are: ethanol from sugarcane in Brazil and three others power generating station in province Ontario in Canada.

6 CASE STUDIES AND ANALYSIES

Methodology in this paper is case study which in this section discusses three biomass case studies in Canada and one in Brazil. These case studies could be used to develop a unity model for biomass energy, and are discussed in detail. These case studies discuss the cost/benefit analysis of power generation stations.

6.1 Case Study #1

This case study analyses the Atikokan Power Generating Station located near the town of Atikokan in northwestern Ontario. You +1'd this publicly. Undo The Atikokan Power Generating Station use to use coal for power generation. This case study provides the cost/benefit analysis of using biomass energy instead of coal for energy production. There are two alternatives through which biomass can be used as a fuel instead of coal. The first option is using sustainable forest harvest and the other option is using agricultural production residues. Sustainable forest biomass will be transported using delivery trucks only whereas agricultural production residual will use trucks and rail for delivery.

The current energy requirement of Atikokan Power Generating Station is about 900 million KWH (Kilo Watt Hour) and this energy is produced by burning 500 megaton's (1 megatons [Mt] = 10^6 tones = 10^9 kg) of lignite coal. At 34% efficiency level, about 9.53 GJ (Giga Joule = 10^{12} Joule) of thermal energy is obtained. It is assumed that biomass will provide the equivalent amount of energy. There are two options through which the power can be supplied.

The first option is to use biomass in the form of wood residues As the plant is surrounded by forest this forest could sustainably provide biomass for years if properly managed. It is assumed that wood contains about 45% moisture content resulting in a lower heat value of 16.9

GJ/t dry biomass. Hence, the energy requirement for the plant would be either about 1.02 Mt in a wet form or 0.56 Mt in a dry form. It is assumed that every year about 0.3% of the forest surrounding the plant can be harvested. The harvesting will give about 175 t of wet biomass material. To harvest this much biomass material, the land requirement would be within 96 km around the town. The wet biomass total cost would be $20.92/t and this figure includes felling costs, the cost of compositing logs from slash, and overhead charges. The estimated cost of transportation from the forest to the plant is about $27.29/t.This cost is same as the cost of electrical power worth $54.81/MWH. It is assumed that the cost of plant operation is about $16/MWH. The federal government renewable energy credit is about $10/MWH and the plant retrofitting capital cost is about $10/MWH. This makes the total cost $70.81/MWH. The total annual cost of about $64MWH/yr would be required for producing power equivalent to about 900 million KWH (Kilo Watt Hour). This is the total cost for case #1. The cost of harvesting and transporting forest biomass cost were estimated from the Ontario Ministry of Natural Resources approved estimates. The development of OMNR's (Ontario Ministry of Natural Resources) Biomass Spatial Analysis Tool (BSAT) model was facilitated by BIOCAP and the result showed that within 200 km of Atikokan, about 2 Mt wet biomass could be harvested on a sustainable basis. However, availability of biomass is not the only thing because a license to use biomass and its related policy must also be studied in detail so that biomass can be extracted on sustainable basis.

The second option is using prairie agricultural residues for the biomass requirement. Under this option, biomass residue in the form of straw would be brought to the site by train from western Canada where millions of tones of residues are available. The crop residues include flax and wheat and there is a small market for it in western Canada. The water content in agriculture residue is very low as compared to the fresh woody biomass. Hence the energy content is also very high as compared to woody biomass. The total biomass requirement of Atikokan power plant in dry form is about 0.59 Mt and in wet form is about 0.73 Mt per year. This biomass amount is sufficient to meet the energy requirement. It is assumed that the cost of biomass at farm gate is about 30$/t (wet) and trucks are required to carry it to trains. The trucks will travel average distance of 100 km and it will cost about $47.50/t (wet). The total distance travelled by train would be about 700 km for about $68.60/t (wet) and this cost include the loading and unloading charges too. The total contribution cost to each of the MWH produced by the power plant is about $55.98. In this case, the plant retrofitting cost is about $10/MWH, the energy credit by the federal government is about $10/MWH, the cost of operation is about $16/MWH. The total cost in this option comes out to be $65MWH/yr. This estimated cost will be able to provide about 900 million KWH power to the grid.

In summary, the cost/benefit analysis of both alternatives shows that biomass energy could be used by the Atikokan power plant for energy for as low as $72/MW. This will be very beneficial for the plant as well as for the environment. The power plant can use the biomass source which is more cost efficient. Tax revenues for the government have not been considered in this case.

6.2 Case Study #2

The second case study is also from Ontario. This case study has the option of using municipal biomass waste to generate power or energy. If the municipal waste is disposed of in landfills it results in various harmful effects, the most important of which are leachate and landfill gas (Statistics Canada 2012) so it is worth finding out how municipal waste can be used otherwise. Hence, the concept of anaerobic digestion of municipal solid waste emerged. Under this concept, solid waste is not disposed in landfills; rather, it is digested anaerobically by microbes in digesters to produce biogas. The biogas is then processed again to produce power or heat, as required. At times, the biogas is also mixed with natural gas in pipelines. During biogas production a rich organic residue is produced which can be used to enrich the soil.

More than one ton of municipal waste is generated by each resident of Ontario (population 12.85 million in 2011) every year. This means the total municipal waste generated from the whole Ontario is about 14,000,000 tones. More than 70% of this municipal waste is disposed in landfill although this trash has about 70% useful biomass. which can be used to generate energy. According to the research in the UK, biomass from municipal solid waste can generate up to 11 GJ of energy per tone. For this research, the estimate is that solid municipal waste in Canada would generate about 9.5 GJ/t energy.

If the 70% of municipal is used for anaerobic digestion instead of disposing in landfills, it will have both wet and dry biomass material. The content of wet biomass in municipal solid waste is about 5.2 Mt and the total energy generated from this would be about 61.7 million GJ. The total biogas produced from municipal solid waste would be about 702 million m^3 while the total methane would be 386 million m^3. Assuming 20% of the biogas is needed to support the anaerobic digesters this means about 10.7 million GJ would be used for generating power. Assuming power generation through a combined cycle plant yielding 5 KWH per m^3 of methane, a total of 1,544 million KWh of electrical power would be generated. It is assumed that the efficiency level of the anaerobic digester is about 80%. The solid municipal waste would be able to support power plants having a capacity of 220MW. About 9% of the solid waste is converted into electrical energy. As the above calculation is based on assumptions, the actual production may vary if the size of the plant differs or the content of solid municipal waste differs. According to the statistics from Europe, ideally an anaerobic digester can process more than 300,000 t of wet biomass material and the design capacity is about 10 MW. In order to process and remove the waste, the municipality would have to pay for it. The calculations suggest that the tipping fees is about $50–60/t of solid municipal waste (Canada's Greenhouse Gas Inventory 2003).

The total net cost for producing electricity at efficiency level as low as 17.3% is about $124.24 per MWH and this does not include the payable tipping fees of $50 per tone. The cost of power generation is reduced due to the tipping fees in anaerobic digester. Hence, the higher the tipping fees the better it is for the anaerobic digester because it reduces the overall cost of production (Canada's Greenhouse Gas Inventory 2003).

Another benefit in using solid municipal waste for power generation is that it does not add to greenhouse gas emissions. If municipal solid waste goes through an anaerobic digester, the decay products (methane, etc.) can be captured and used and hence the environment is protected. If the waste is disposed in landfills, the total emission from the landfill is equal to 7.97 Mt emissions of carbon dioxide annually and this is lost to the atmosphere and is not used. Although anaerobic digesters also produce green house emissions the content is very low compared to landfill emissions. It is assumed that about 50% of green house emissions come from landfills and if the waste is processed in anaerobic digester, the emissions would reduce to 20%which is very much less. Hence, it is much better to use anaerobic digesters to produce power from solid municipal waste rather than disposing in landfills. The tipping fees in this case would also reduce the cost of power generation which is another incentive for industry. The main advantage of using municipal waste for power generation is that the total cost of power production is lower and the environment becomes safer. The calculations above do not take into account the greenhouse emissions credit given by the government when solid municipal waste is used an input for power generation. The government also gives different incentives to industries that use biomass material as their input for producing power.

To conclude, landfills are associated with high cost and are harmful for the environment. The main reason for developing municipal solid waste anaerobic digesters is to minimize the cost of waste material and keep the environment clean. As energy and fossil fuels price increase alternative sources of energy are more and more promising. Governments play a vital role in this regard. The government gives incentives in the form of green house gases credits and tipping fees which lower the cost of power production. Using solid waste as an input, more than 220 MW of base load could be added to support Canada's energy requirements.

6.3 Case Study #3

The third case given here is of Nanticoke power generating station in southern Ontario, one of the largest power generation coal power plants in North America. This power generation centre generates more than 22,900 million KWH/yr from a coal input of 9 Mt. The input for producing this electrical energy is coal imported from United States. In this study, two options for producing energy are analyzed, co-firing and biomass. The level of efficiency of the Nanticoke plant is about 34%. The total annual input of thermal energy to produce the KWH cited above at this given level of efficiency is about 243 million GJ. Therefore, if the quantity of fossil fuel (coal) is to be replaced entirely by biomass then enough biomass to produce 243 million GJ is needed. Because Nanticoke is located near an agricultural region, according to recent statistics from the David Suzuki Foundation, agricultural residue worth 3.5 Mt is available from that agricultural region. In order to meet a small part of the Nanticoke needs of energy, about 0.76 Mt of dry biomass, which represents about 8% of the coal needed, is easily available. Since the agricultural region is about 155 km away, transportation would be needed to move the residue from the agricultural region to the power station. This will be done at a total delivery cost of $47.93/MWH.

The second option is to use forest biomass instead of or in addition to agricultural biomass. It is very challenging for the power plant to replace the coal with only biomass material. Forest biomass material is easily available but the cost of delivery is high in this case. Four sources of biomass material could be used to replace the coal. The power plant would generate 5% energy from the crops residues. The biomass crops (not wood) will generate 55%of the energy. This biomass material would be brought by truck and the rest of the biomass would be brought by ship. The total investment required for this would be $600M/yr to provide sufficient level of biomass material. The main regions from where the biomass material can be acquired include NY, Michigan, Quebec or Ontario. The research by David Suzuki Foundation indicates that the biomass material could be planted into 77% of the nearby cropland. This could be done so by reducing the cropland by 10%, reducing hay land by 30% and improve pasture by 30%. The remaining requirement can be fulfilled either from outside the province or giving incentives to rural people to enter farming (that produces biomass residues). The total cost for delivery of the biomass to the plant is about $70/MWH. It should be noted here that the cost is only estimated. The real cost may vary by some percentage. Forest biomass can be used to fulfill the remaining biomass requirement. For this, biomass residue from the forest must be collected. Paper and pulp industry waste can also be used for producing energy. The above calculations are based on the assumption that the US and Canadian ports are being used by the plant for shipping biomass material. The total delivery cost for the biomass material is very expensive compared to other biomass sources. Many policy changes are required so that this biomass material is made available at a cheaper rate

At 34% conversion efficiency, the total delivered cost of the biomass material is \$6.51/GJ and at this level of conversion rate, \$69/MWH power is generated. About \$10/KWH capital cost is added to above figure and about \$16/MWH is also added. This increases the gross price to \$95/MWH. The government credit of \$10/MWH for renewable energy reduces the cost to \$85/MWH.

To conclude, there are many actual or potential biomass sources in Ontario which could meet the needs of the Nanticoke power station at a lowest possible price, i.e., \$85/MWH. The government of Ontario will need major simulations to the province rural economy if it chose the base power generation option. This applies to both sectors: forestry and agriculture. What is required is an integrated approach that addresses environmental and energy issues collectively. This integrated approach must take into account the needs of society as well as the environment.

6.4 Case study #4

Brazil is the second largest producer and the largest exporter of bio-ethanol in the world. It is one of the few countries in where it is possible to increase both food and biofuels production. In 2007 the country produced 5 billion and consumed and 4.1 billion gallons of ethanol (RFA, 2009, Giannetti Da Fonseca, 2008). Due to its tropical climate and continuous growing season this can be uniquely complementary, where food and biofuel production can occur without competing. Brazil obtains continuous productivity gains for its major agricultural production chains (food and biofuel crops) without environmental hazards. Brazilian sugarcane ethanol has significant performance advantages over ethanol produced from other crops. First, the energy conversation from sugarcane feedstock is four-times higher than from wheat, beet sugar, or corn (Wright, 2008). Second, production costs associated with Brazilian ethanol are ~\$0.80/US gallon compared with ~\$1.30/ US gallon for US corn and ~\$1.70 for EU wheat or beet sugar (Budny and Sotero, 2007). Improvements in industrial knowledge and efficiency in ethanol use have allowed four times the original mileage per hectare, maintaining a relatively low cost of ethanol relative to petroleum. These performance advantages reflect Brazil's commitment to investment in sugar varietals and efficient process manufacturing. (DeWitt A. et al 2009, Bio-ethanol Cluster in Brazil 2009).

The Brazilian company Proálcool was a program of supply-side and demand-side measures to support development of the sugarcane ethanol industry. On the supply side, interest rates were reduced for loans used to construct ethanol distillation capacity, while ethanol price floors and guaranteed purchases by Petrobras (the state-owned oil company and monopoly distributor of ethanol) ensured a minimum revenue stream to producers (Martines-Filho et al. 2006). In addition, the government itself invested heavily in mills that could switch between ethanol and sugar production (Rothkopf 2007).

Today, sugar and ethanol production account for 3.5% of Brazilian GDP and employ more than 3 million workers. Furthermore, it seems that today's largest ethanol producer, the United States, also could not have been as competitive as Brazil's ethanol cluster. The US mostly lacks the climate necessary for sugarcane growth (producing only 4 million tons versus Brazil's 528 million in 2008). Thus, having to settle for corn, the much more plentiful American feedstock, the ethanol industry in the US has not been able to enjoy the competitive advantages of sugarcane ethanol (Cox, 2007, Bio-ethanol Cluster in Brazil 2009)

Corn is four-times less energy efficient and nearly three times costlier to produce; it is also much more land-intensive and more directly compromises the food supply, diminishing its sustainability (Wright, 2008, Budny and Sotero, 2007).

The ethanol cluster benefits from Brazil's natural endowments i.e. a suitable combination of land, water, and climate for sugarcane production. Sophisticated financial markets as well as strong agricultural and bio-fuels research institutions are also helpful. However, , several factors adversely impact the cluster, namely, poor domestic transport, poor export infrastructure and limited qualified labour (Bio-ethanol Cluster in Brazil 2009).

Transport by roads, waterways and railways, and export via ports accounts for roughly 10-20% of the ethanol cost structure; thus, quality of transport infrastructure can materially affect the competitiveness of ethanol (Babcock 2006). Moreover, poor transportation, as identified earlier, also limits the wider geographic use of ethanol within Brazil and in the future, to foreign markets. Another weak factor condition is the limited availability of specialized labor. Currently, 0.8% of the population is graduating as engineers in Brazil, versus 2.2% in the US and 3.3% in Germany (Rothkopf 2007). Due to limited enrollment in specialized fields (agrarian sciences, microbiology, and engineering), the country lacks the pipeline of researchers necessary to generate innovations in the cluster. (Bio-ethanol Cluster in Brazil 2009)

Related and Supporting Industries. Primary supporting industries for bio-ethanol are sugarcane harvesting and sugar production. Brazil is the world's largest sugar producer and exporter, with 37% of the world export share (Bobovnikova and Miura 2008). In 2007 two-thirds of Brazil's sugar production was exported and one-third was consumed domestically (Rozenbaum 2008, Bio-ethanol Cluster in Brazil 2009)

Since only 0.6% of Brazil's arable land is devoted to sugarcane production, the country has significant opportunity to expand to meet increased demand (Rothkopf 2007). Brazil's sugar industry is also highly productive. Sugarcane yield per hectare increased by 33% between 1975 and 2000, and sugar content of cane increased by 8% in the same time period (Xavier 2007).

Although most of Brazil's sugar producers can switch between sugar and ethanol production, ethanol production is frequently the more attractive choice because the global sugar industry is highly protected and plagued with overproduction. Tightening environmental standards and the desire to reduce dependence on oil stands to increase Brazil's exports of ethanol in the future. However, many barriers are in place. First, import tariffs in the largest consumer markets are substantial. The US tariff is US$0.54/gallon (Budny and Sotero, 2007) and the EU tariff is US$0.49/gallon (Tokgoz 2009). Additional non-tariff barriers include a lack of common international standards in ethanol chemical composition, concentration and processing. Finally, many potential markets lack necessary supporting infrastructure and complementary goods; for instance, the number of ethanol stations per million people is 174 in Brazil versus 6 in the US and less than 6 in the EU (Budny and Sotero 2007).

Fortunately, flex-fuel vehicles are available in the US and the EU at comparable prices to traditional engine vehicles; however, with the large existing base of cars (the US fleet is roughly 7x that of Brazil), transforming the existing car fleet in these developed markets is a challenging and lengthy process. (Bio-ethanol Cluster in Brazil 2009).

To conclude, equatorial countries such as Brazil that have a suitable combination of sufficient land area and suitable climate for efficient production of bio-energy crops have an advantage over other countries and should capitalize on this, both for domestic production of biofuels and for their export. Brazil has shown that biofuel production is cost effective.

7. SUCCESS AND FAILURE FACTORS

Biomass is the world's fourth largest energy source and the first in developing countries representing 14% and 35%, respectively, of primary energy. The provision and use of biomass energy is a complex issue; it is an integral part of the problems associated with sustainability of all types of vegetation which in turn is a key to ensuring stable socioeconomic development. In USA obtains 4% of its energy from biomass, and Sweden about 14%; both countries have plans to increase bioenergy production and use. Annual resources of biomass are eight times the world's energy-use but the problem is getting the energy to those who need it in an environmentally sustainable manner, and which is also economic when all internal and external costs are accounted for. There is considerable scope to modernize biomass energy production delivery systems to provide varied energy carriers such as electricity, liquid fuels and gases.

The financial costs of producing biomass are also very complex since they depend upon many different factors and tend to be quite site specific, e.g. agricultural and forestry costs, type of feedstock and its productivity, equipment requirements, etc. The last two decades have witnessed numerous proclamations of failure and success of biomass schemes. There is no short cut to trying to understand the factors required for success except by extensive investigation. Most likely with considering the socioeconomic and technological implications of four case studies which are in this paper and discussed on detail above.

There are two important factors in Canadian biomass energy sector. Those are energy production and waste disposal. Both have different environmental affects.

More than 22 million tons/yr of solid biomass is disposed of by Canadian energy industry. Many industries in Canada use biomass as an alternative fuel in power plants so there is a market for biomass residues. Biomass not used to produce energy is dealt with in various ways. Forest biomass may be left in the forest, waste industrial/construction wood may be disposed of in landfills, some waste wood may be composted and spread on the land, or wood chips and bark may be used as mulch and cover.

There is a lot of controversy about using biomass as a sustainable energy source on a large scale. The success factors and failure factors of using biomass as an alternative energy source vary with geographic location (country) and local energy needs. Biomass energy sources like all other energy sources affect the environment and have its negative aspects as well. These risks and impacts (failure factors) include sustainability, air quality, carbon emission, cost, and burial. These will vary with region. (Trawick 2001).

Biomass sources can be divided into beneficial which are can be consider as a success factors and harmful that consider it as failure factors. Harmful biomass resources and practices include clearing forest, savannah or grassland to grow energy crops, and displacing food production for bioenergy production that ultimately leads to the clearing of carbon-rich ecosystems to grow food. Harmful biomass adds net carbon to the atmosphere by either directly or indirectly decreasing the overall amount of carbon stored in plants and soil. A wide range of biomass resources are beneficial and consider it success factors because they clearly reduce overall carbon emission and provide other benefits. Beneficial biomass includes 1) energy crops that don't compete with food crops for land, 2) portions of crop residues such as wheat straw or corn stover, 3) sustainably-harvested wood and forest residues, 4) clean municipal and industrial waste (Tillman et al. 2009). Energy from beneficial biomass sources is environmentally friendly and, if used efficiently, can partially fulfill our energy needs. The best reason for using biomass energy is that it is renewable, unlike fossil fuels (success factors).

Depending on the situation, benefits of using biomass include lower operating cost, reduction in emissions harmful to the environment and human health, and more reliable energy source. Renewable energy sources are more secure than conventional fossil fuels because they are not affected by geopolitical considerations. Use of renewable energy sources (RES) creates new competition which helps in restraining fossil fuel price increases and insulates the nation's economy from fossil fuel price spikes and supply shortages or disruptions. Adding even small amounts of energy can make a significant difference in remote rural areas and hence higher costs are justifiable. Use of RES diversifies the options to generate power; increases local job opportunities and may improve the standard of living (if beneficial and not harmful biomass is used).

As a result I can classify the success factors, and failure factors for biomass energy as general and especially in the above case studies:

1) The most important success factor and positive advantage of using biomass is reduction of carbon dioxide emissions, which contribute to the greenhouse effect, which results in global warming. For example, Canada produces about 600 million tons of carbon dioxide every year. On a global scale, that represents billions of tones of carbon dioxide every year (Cowie 2013). On a world basis, this gas will be reduced to the extent that biomass replaces fossil fuels. If sufficient replanting occurs, more carbon is taken up (recycled) by plants grown to replace the biomass removed for energy production than is released into the atmosphere, resulting in lower or negative carbon emissions. If the biomass resource is being used sustainably, there are no net carbon emissions over the time frame of a cycle of biomass production.

The amount of non-carbon compounds, e.g., sulfur and nitrogen compounds and heavy metals, e.g. mercury, is less in most biomass sources compared to the amount in coal and natural gas. Hence, the emissions by biomass plants are less compared to coal-fired plants. Effective and sustainable biomass sources vary from region to region so local reductions in carbon dioxide will also vary.

2) The second success factor and advantage of using biomass as a source of energy is that it is relatively widely available as forest, crop or animal residues. As the world population increases, the amount of waste generated also increases. This waste can also be used as a local biomass source for fuel production.

3) A third important factor and advantage of converting energy from solid waste is that it reduces amount of garbage dumped in landfills considerably. This is particularly important in countries or urban areas where there is little or no room to bury garbage in the ground.

4) Finally, there are social and psychological benefits, including increased opportunities for economic development in rural areas and the perception by people that they are doing something good for the environment.

5) For failure factors I can hint to reduce air quality which includes carbon, and other emissions. Other emissions, e.g., Sulphur (SO_2, SO_4) compound, nitrogen compounds (NO_2, NO_4) and heavy metals, e.g., mercury, lead. These non-carbon emissions from converting biomass to energy may affect air quality (causing smog and acid rain) and therefore human health. The amount and kind of emissions from biomass combustion depends the technology used for conversion and the air cleaning devices installed in the power plants. Bad smells are produced when certain types of biomass, e.g. sewage, are converted into energy.

One of the main sources of pollution in the world is from burning agricultural and forestry biomass residues. Smoke, CO_x NO_x, and sulphur compounds are emitted into the air when biomass is burnt in the open and air quality becomes poorer. Some of these gases contribute to the ozone layer depletion. The volume of emissions cannot be quantified because there is lot of variability in environmental conditions. However, if the residues are used as a fuel in power plants, the volume of emissions can be reduced. So governments discourage foresters and farmers from burning residue in the open. Agricultural burning is banned in most of the areas of the world (although it still frequently happens). In Canada, agricultural residue burning is not allowed. Biomass energy power plant development solves the problem of open burning. Governments encourage factor or mill owners to use biomass residue as their fuel source so that it does not get disposed by burning in the open. To the extent that biomass is burned power plant the emissions of greenhouse and other gases into the atmosphere is reduced.

The process of converting biomass into energy or fuel releases many gases which can harm the environment because the carbon content in biomass material is as high as in fossil fuels. When biomass material is converted to energy, part of its carbon content is emitted into the air as carbon dioxide. The amount of carbon dioxide released in the atmosphere is increased if the source of biomass energy is not replaced. Thus, deforestation without replanting leads to increased content of carbon dioxide in the air. In some cases, biofuels are more harmful than fossil fuels if the biomass material is not completely converted into biofuel during combustion due to poor technology. For example, charcoal produced due to incomplete combustion is very harmful for the environment.

6) The carbon cycle is broken, i.e., soil, which is an essential link in the cycle of life (Doran 2002), is not replenished with decaying plants and animals which would normally re-fertilize the soil with organic nutrients and the physical structure of soil is also negatively affected. Soil re-generated by artificial inputs of chemical fertilizers is only a partial and short term solution because the physical structure of soil is not maintained, and production of fertilizers costs a lot of energy derived in part from fossil fuels.

7) Cost, Perhaps the most important failure factor of using biomass material as an energy source is the high cost of harvesting and transporting biomass material. This means that energy produced from biomass material may be less than the actual energy input for energy production. Because of this many foresters and farmers prefer to leave the residues in the field or forest. Another important negative aspect to cost is that of training experts to build cost- and energy efficient biomass power plants, and the initial investment in industrial-size biomass plants is very high so only rich, developed countries can afford to have them. Therefore, developing countries cannot afford these. At present, the cost of renewable energy from biomass compared to that of fossil fuels is much greater in many countries. Until costs are reduced to about the same as for fossil fuels there is little incentive to use biomass for energy production. Finally, biomass fuels are less useful compared to fossil fuels because a huge bulk of biomass material is needed to produce useful amounts of energy compared to fossil fuels, the process is slow and net energy produced is low. Power generating companies are of opinion that if there is no return on investment, they can't invest huge capital in biomass plants only because it is good for environment. The government can play its role in this regard by encouraging business incentives like imposing taxation on use of fossil fuels or making the use of biomass material compulsory for few industries or offering attractive incentives to industry owners to use biomass material for energy production. Government's role is very important in this regard as fiscal benefits can be offered only by it. Companies which implement biomass plants on large scale will also enjoy economies of scale and will be able to produce energy at a cheaper rate. Using state of art technology can minimize the risk and increase the profitability of the business. In future, if more efficient and state of the art technology is used in biomass plant design and construction, only then can biomass sources can be used to produce bio fuel from crops economically.

8) Burial, if biomass is disposed in landfills it reduces their capacity and greenhouse gas emission will increase. Sanitary landfills contain about 20% of total wood waste, either as household garbage or otherwise (e.g., construction). The wood waste is buried in landfills when it is not used as fuel power plants to generate electricity for industry. Although some of the wooden waste ends up being used as landfill cover or some other application the fraction used this way is very small. Due to burial of wood biomass material in landfills, stabilization of the landfills is delayed. And when wood biomass degrades in landfills harmful emissions, include methane and carbon dioxide, are produced. The solution to reducing the environmental impact of biomass burial is to extract as much woody residue from garbage or construction leftovers as possible so it does not enter landfills but is burned in power plants instead.

8. RECOMMENDATION

People are looking for ways to incorporate biomass material to produce energy because energy needs are increasing worldwide. Present technological advances in renewable energy sources make biomass energy more cost-effective and efficient than in the past. A modeling power software system exists to analyze the economic and environmental costs/impacts of using biomass for energy production: the Hybrid Optimization Model for Electric Renewable (HOMER). HOMER is a design model that determines the optimal architecture and control strategy of a hybrid system. The developed hybrid systems include different combinations of diesel, renewable energy sources, photovoltaic cells, or batteries. These hybrid systems are especially applicable for remote villages. HOMER software has been used to study economic feasibility and environmental impact of biomass resources. The amount of the carbon dioxide emissions from different biomass fuels and of the diesel may be studied and analyzed using HOMER.

Based on given ratings, HOMER builds all possible combinations and calculates an optimal solution. It ranks the systems according to the Net Present Cost (NPC). Different biomass energy types, i.e., agricultural residues, energy crops, forest residues, and animal waste are taken as the inputs to the modeled power system and cost optimization analysis is developed. The NPC is taken as the measure to analyze economic aspects as well as to compare biomass economics with diesel.

HOMER assumes the biomass feedstock is fed into a gasifier to create biogas. One or more generators then consume the biogas to produce electricity. In the cost window, one can give the size of the generator, its capital, replacement, and operational and maintenance cost as inputs to the generator. Based on the user's data for size and cost, it will automatically update the cost curve. In the fuel window, the type of fuel can be specified, i.e., whether it is biomass, diesel, gasoline, or natural gas. In the schedule tab, the user can indicate whether he or she wants the generator to be ON/OFF at a particular time. The emissions window helps the user to include the amount of carbon monoxide, unburned hydrocarbons, particulate matter, fuel sulfur, or nitrogen oxides released by generating using the particular type of source. HOMER also can perform sensitivity of outputs to the changes in inputs. Different sizes of the generator, e.g., 500 kW, 1100kW, 1209kW, and 1300kW, may be considered to study sensitivity analysis as well as the economic architecture of the power system. These sizes of the generators are chosen such that it produces power equal to the peak load, above peak load, and below peak load.

Growing and/or harvesting biomass, transporting it to where it can be used for energy production, and converting it into suitable energy forms for the purposes required are the three aspects that determine its cost, whether it can or should be used at all, and whether it will be beneficial or harmful compared to using some other form of energy. These factors will have different importance depending on geographical location and local resources. Biomass is potentially a valuable source of energy, particularly in less developed countries that either do not have or cannot pay for fossil fuels. Even if less developed countries do not have the technology to build and operate efficient plants to convert biomass to energy it is still cost effective for them to use biomass. In 1983, 14% of global energy consumption came from biomass (Hall et al. 1983). In 2005, it was the same percentage (Balat and Ayar 2005). Thus, over that period of 22 years there was no increase in percentage of global energy production using biomass. However, biomass must be monitored carefully so as not to destroy forest and agricultural land and soil fertility, i.e., the carbon cycle must not be broken or else severe soil erosion will occur. This can only partly be replaced by adding fertilizers that are themselves dependent on fossil fuel use to extract from the ground. Obtaining biomass for energy production from crop plants, e.g., sugarcane is more economically feasible and cost effective in countries at or near the equator than from higher latitude countries, e.g., Canada, because the amount of solar energy is greater per m^2 so several crops can be grown per year instead of only one. So in tropical countries biomass is actually (e.g., Brazil) or potentially a better source of energy than in higher latitude countries. Other concerns are: the expected competition of biomass with its multiple uses including the use of energy generation, biomaterials and food (Muller 2008). The increase in the prices of corn in Mexico as a result of increase in the demand of bio-ethanol factories in USA is repeatedly making this phenomenon obvious. The competition for water is similar to the competition for land. The extent to which alternate fuels such as biomass are developed will depend partly on government support and funds. Without this support biomass as an alternative source of energy will not be developed because the price of coal, oil and natural gas are relatively low and the initial price of biomass energy is high. If the prices of fossil fuels increase, people may choose biomass sources for producing useful energy. Currently, biomass energy is being used in areas where other energy forms are not available, e.g., as in developing countries, and is renewable if used properly.

9. SUMMARY AND CONCLUSIONS

Biomass is the most important **renewable** energy source in the world. The importance of biomass as a fuel source may increase for some countries, e.g., in Europe, as their national energy policies and strategies focus more heavily on renewable sources and conservation.

It has a broad range of uses and users, and known as a renewable energy sources, but biomass is also used for human food, animal feed, materials and chemicals, and bio-energy interacts with all these areas. Non renewable energy sources such as coal, natural gas, and oil are hazardous to the environment due to the emissions of their produce. Biomass can be defined as any organic matter which is available on a renewable basis. This includes residues of forests, municipal wastes, crops and waste of the agriculture field, Biomass is thus a term for all organic material that comes originally from plants. It is also dry weight of all organic material, living or dead, above or below the soil surface. Biomass is produced by green plants converting sunlight into plant material through photosynthesis and includes all land- and water-based vegetation as well as all natural organic wastes.

Before getting to biomass as an alternative energy source, it is very important to look at cost, and the benefits versus the detriments of using biomass for energy. Based on the results obtained for this thesis the following conclusions are made.

Biomass energy reduces the need for fossil fuels and therefore may lead to reduced greenhouse gas emissions and, hopefully, reduces global warming by an amount corresponding to the reduced amount of fossil fuel burned. Therefore, possibly the best and cheapest source of biomass energy is from a) industrial and household waste because it does not break the carbon cycle and result in loss in soil fertility and it results in much less garbage being disposed of in increasingly hard to find landfill sites, and b) wood waste from sawmills to produce energy for the mills themselves.

In wealth, industrialized countries use of biomass as a fuel source is seen as psychologically and socially beneficial because at least some people feel that they are doing something useful to protect the environment. Fossil fuels (oil, coal and natural gas) will not be replaced completely with biomass and other alternate energy sources. But it is feasible to use biomass as an alternate source of energy to complement fossil fuels and other energy sources, e.g., wind or solar energy.

The worldwide amount energy consumed from biomass in 2005 was about 264 Gigawatts (GW) for electricity production and heating together and, in addition, 33 billion liters of ethanol (Wikipedia 2013b). Biomass used for cooking was not included in this figure. In future, biomass has some potential for some countries to provide a cost-effective and sustainable supply of energy, while at the same time aiding countries in meeting their greenhouse gas reduction targets. It is important to note here that the collection of fuel from European forestry and agriculture and the use of energy crops is a sustainable activity that does not deplete future resources (Balat and Ayar 2005).

Regardless of the competition for agricultural land, i.e., crops for food or crops for biomass, or forested land, i.e. trees for wood or trees for burning (in the form of dried wood pellets, for example) to provide energy, the problem of environmental sustainability has to be addressed. Biomass material can be useful if and only if it is used on sustainable basis.

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